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# The Human Collision





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# The Human Collision

how injuries occur...  
how seat belts prevent them

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# Introduction

Motor vehicle accidents are a serious social and economic problem. In Ontario, one out of every three reported accidents results in injury and one in every hundred results in death. During 1973, there were nearly 100,000 people injured and 2,000 killed in traffic accidents. Serious accidents are especially frequent among younger people. For people under the age of 35, traffic accidents are responsible for more deaths than any disease and for more deaths than all other accidents combined.

The use of seat belts dramatically reduces the risk of injury and death. Scientific evidence strongly supports the value of seat belts, yet only a small proportion of people actually use them. People do not wear seat belts for a variety of reasons: fear that the seat belts will trap them in their cars; the belief that good drivers don't need them. Some people feel that they are just too much trouble.

This booklet provides information to help you decide, on the basis of the available scientific evidence, whether or not seat belts are worth the trouble it takes to use them.

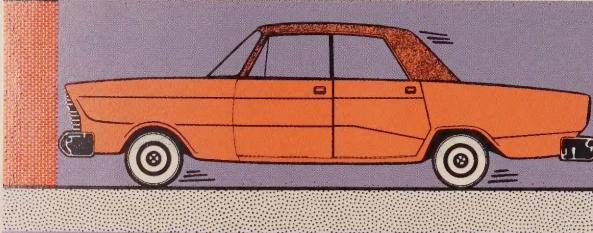
# What happens in a collision

In recent years, collisions have been studied in an effort to improve the chances for survival. Extreme slow-motion film and instruments for measuring forces have been used in these studies. As a result, we now have a good understanding of what happens to the car and to the people inside during a collision.

It has become clear that there are really two kinds of collisions within a single accident. The first is the car's collision in which the car hits something, buckles and bends, and then comes to a stop. The second and more important collision is the "human collision" which happens when a person's body or head hits some part of the car. It is the human collision that causes injury.

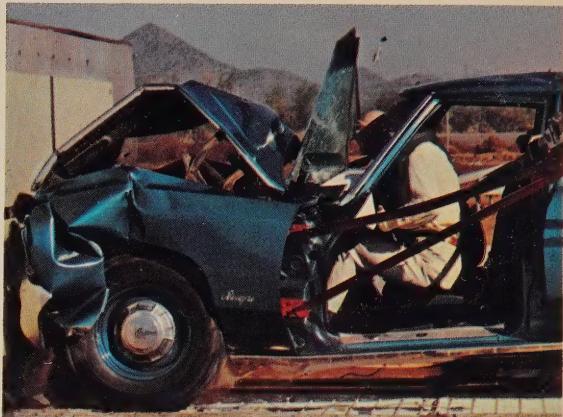
## The Car's Collision

A crash into a solid barrier at 30 miles per hour is a severe accident. It involves the same force as hitting a parked car at 50 miles per hour since the parked car will move a little while the solid barrier will not.

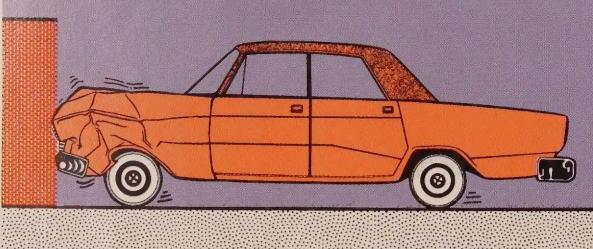


Because the solid barrier does not move, the car is forced to stop. The front bumper is the first part of the car to come in contact with the barrier and it stops immediately. Within one-tenth of a second, the front of the car crushes about two feet and the car comes to a complete stop.

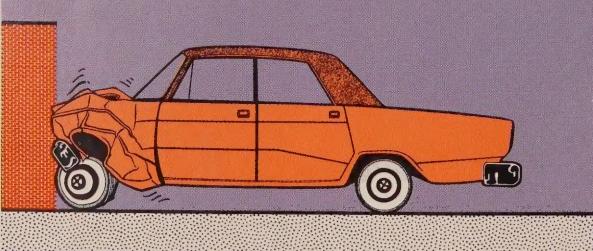
The crushing of the front end serves as a cushion for the rest of the car, and helps absorb the shock of the collision. As a result, the passenger compartment comes to a more gradual stop than the front of the car, and it remains undamaged by the collision.



*A test-track crash into a barrier at 30 mph.*



*When a car hits a solid barrier, it doesn't stop all at once. The bumper stops immediately but the rest of the car continues to move forward.*



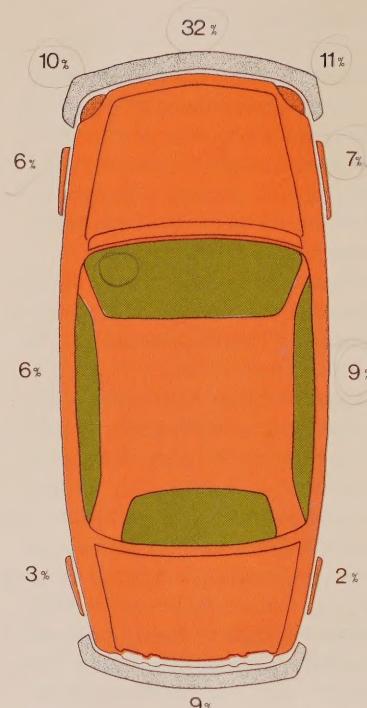
*The car slows down as the crushing of the front end absorbs some of the force of the collision.*

*At 30 mph, it takes about 1/10 of a second for the car to come to a complete stop. The front end will be crushed but the passenger compartment will usually remain undamaged by the collision.*

Even in severe collisions, the passenger compartment usually remains in good shape. If a collision occurs at an extremely high speed or if the car is hit broadside, the passenger compartment can be partially crushed. Fortunately, however, this happens in only a small minority of all collisions. In the great majority of accidents, the front or rear end of the car sustains most of the damage. The passenger compartment usually is not damaged at all by the vehicle's collision. Instead it is damaged by the human collision — by a person striking it with his head or body.

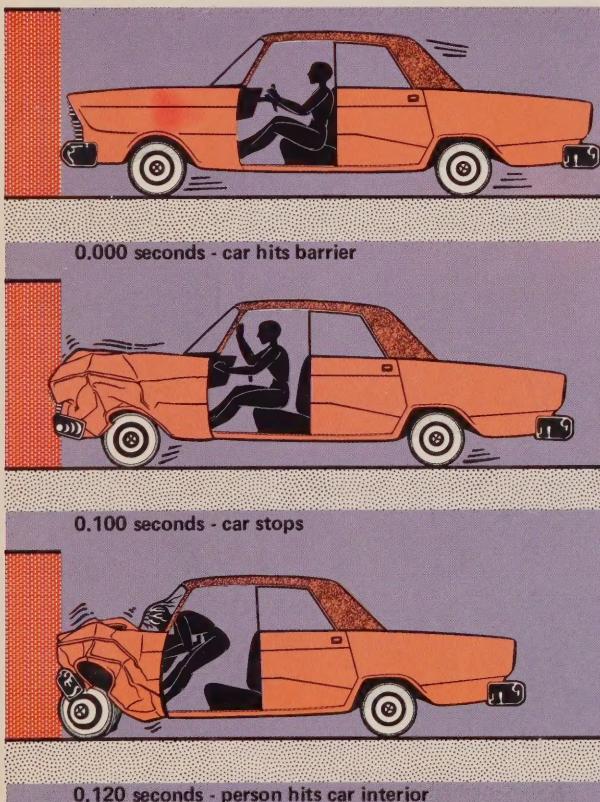
### The Human Collision

In our example of a 30-mile per hour barrier crash, the car is crushed a couple of feet and comes to a stop about one-tenth of a second after hitting the barrier. Slow-motion film would show that the people keep moving inside the passenger compartment at 30 miles per hour. They continue moving inside the car during the one-tenth of a second that the car takes to stop. The people are still moving forward at their original speed when they slam into the steering wheel, windshield or some other part of the car. This is the human collision.



**Percentages of Primary Impact in Urban Accidents**

*There are fewer side impacts in highway collisions  
(G. M. Mackay and C. P. de Fonseka, 1967)*



*On impact, the car begins to crush and to slow down. The person inside the car has nothing to slow him down so he continues to move forward inside the car at 30 mph.*

*Within 1/10 of a second, the car has come to a complete stop. The person is still moving forward at 30 mph.*

*One-fiftieth of a second after the car has stopped, the person slams into the dashboard and windshield. This is the human collision. In the car's collision it takes 1/10 of a second to stop; in the human collision it takes only 1/100 of a second.*

## It's the Human Collision That Hurts

Some people believe that they can protect themselves in a crash by holding onto the steering wheel, or bracing themselves with their arms or legs. Collisions usually happen too fast to permit this. Even if there is time to brace yourself, the forces involved in a collision are too great to withstand — even at moderate speeds. In a 30-mile per hour barrier crash, an occupant strikes the interior of the car with a force of several thousand pounds, causing serious injury to himself and damage to the interior of the car.

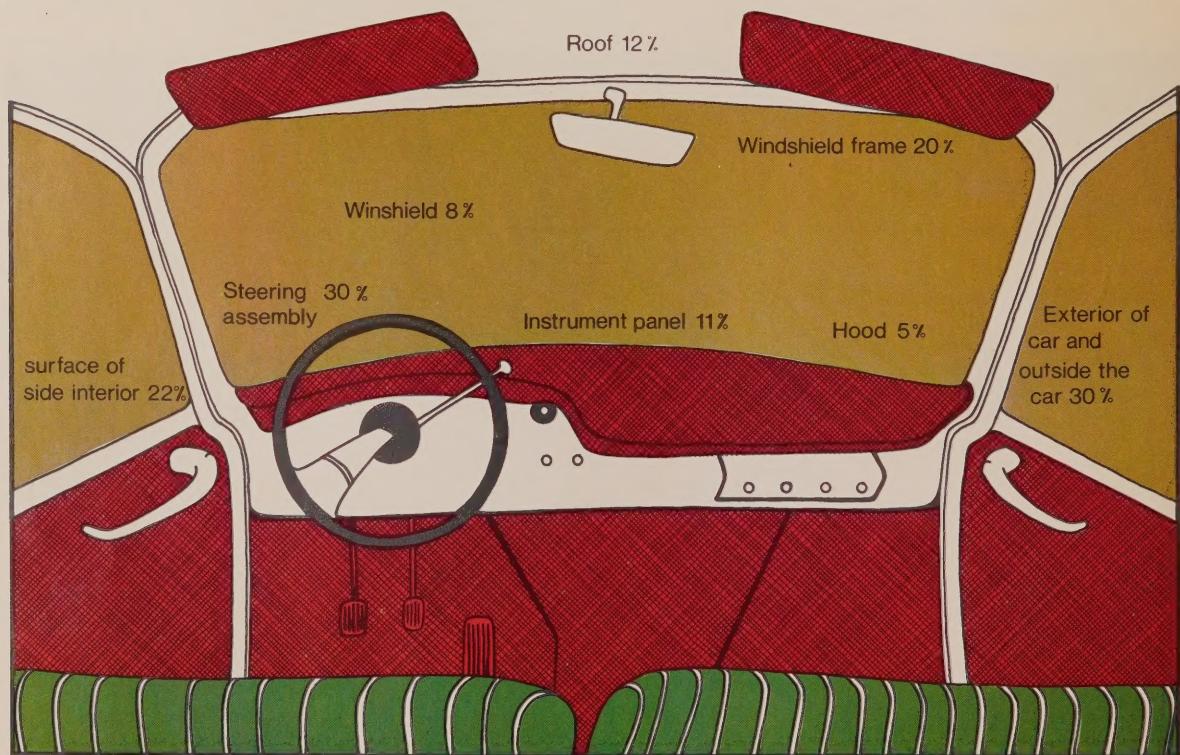
It is not easy to appreciate just how severe the human collision can be even in low-speed crashes. To help understand what happens, imagine someone walking briskly head-first into a steel post. This would be about a 3 or 4-mile per hour collision. The person would probably survive without serious injury. Then imagine him running full speed into the steel post. If he ran fast, this would be about a 15-mile per hour collision. His injuries would be severe — he might not survive. Now imagine his head striking the post at 30 miles per hour. The force would be four times greater than at 15 miles per hour and the person would not survive.

Most parts of the car interior provide little padding and severe injuries to the head and chest can result

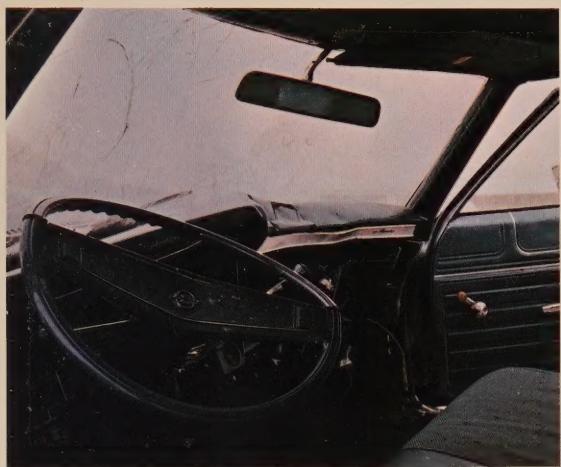


*Serious damage to the front end of this car resulted from a head-on collision.*

from minor accidents. For example, a person flying around inside a car can strike the windshield, the windshield frame or a door post. All of these are hard and unyielding. When a person hits something hard he must come to a stop over a very short distance because the surface will give way very little. His body must absorb most of the force of the impact.



*The above diagram shows the percentage of occupants who were fatally injured by different objects inside the car. For example, the steering assembly caused fatal injuries to 30% of persons involved in collisions. Frequently an occupant was injured by hitting more than one object. As a result, the percentages add to more than 100%. (Wilson and Savage, 1973)*



The interior of the car shown to the left indicates that one of the occupants hit the windshield and likely received serious injuries to the head and face.



This car was involved in a side collision. The car door was bent by one of the occupants who was thrown against it.

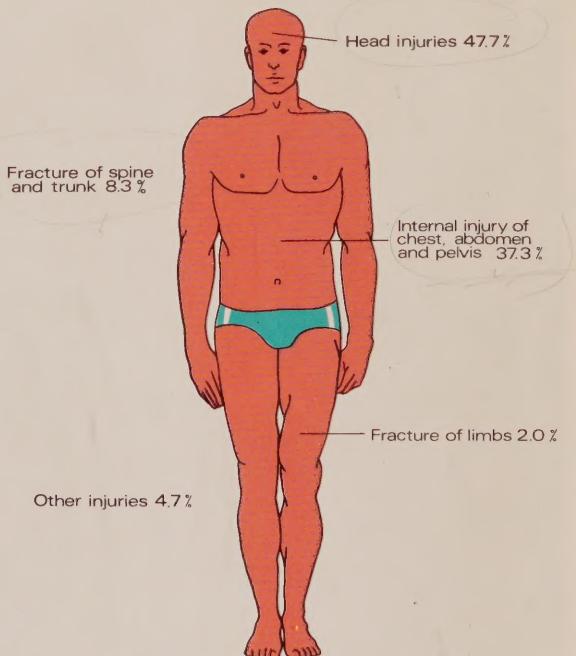


The interior of the same car shows that the passenger hit the windshield pillar and the door.

When an occupant hits a hard edge, a knob or a lever, all of the force of the impact is absorbed by only a small part of his body's surface. Severe injury from hard or sharp objects can result even in a relatively minor crash. For example, gearshift levers have been known to penetrate the skull and cause death.

If a person hits the steering wheel or a padded portion of the interior, some of the force is absorbed by the car. Except in extremely low-speed collisions, this will not be enough to protect the occupant from injuries. Padded dashboards and collapsible steering columns provide only a few inches of cushioning. If an occupant's head hits a well-padded dashboard at more than 30 miles per hour, serious injury will result.

Chest injuries from the steering column are common in car accidents. Also, facial disfigurement often results from being thrown into the windshield. In fact, head and chest injuries are the most frequent cause of death in collisions. In Ontario, about half of fatal accident victims die of head injuries.



**Percentages of Fatal Injuries Sustained in Vehicle Collisions**  
Injuries to the head are the most frequent cause of death in vehicle collisions.

## Person-To-Person

In a collision, passengers tend to move towards the point of impact — not away from it as might be expected. The tendency of everyone in the car to move in the same direction during a collision sometimes gives the term "human collision" special meaning.

In a frontal collision, drivers and front seat passengers can receive serious neck and spinal injuries from rear seat passengers who fly into the front seat a fraction of a second after impact. People can bump heads with fatal force and, in a side collision, a person can be hurled against the passenger next to him and force him out the window or door. Considering that people normally weigh between 100 and 200 pounds, it is not surprising that high-speed, person-to-person contact during collisions is a common source of injury.

People often carry young children on their laps while riding in a car. This can lead to another form of human collision. Accident cases have shown that mothers can crush their children against the dashboard during a crash. Even in relatively minor accidents or panic stops, a child can be pulled away with surprising force and hit the dashboard or floor.



*Unbelted rear seat passengers can be thrown into the front seat and*



*In a crash or sudden stop, an adult can crush a child against the dashboard.*



Injure the driver and other front seat passengers.

## Seat belts prevent the human collision

### It's Not the Fall — It's the Stop at the End

The first attempts to research the human body's ability to withstand crash forces were begun in the early 1940s by Hugh DeHaven. During investigations of air crashes, he became interested in "miraculous" survivals. This interest led DeHaven to look for other instances of extraordinary survival. He studied cases in which people had survived falls from high places. Through analysis of these "freefall" case histories, he demonstrated that under special circumstances the body could withstand extreme forces.

In each case of freefall survival, the person landed on something like soft ground, an automobile roof, or a roof top that absorbed some of the force created by the fall. When the body landed, the surface gave way a few inches. These few inches allowed the body to come to a more gradual stop than if it had landed on a hard surface. If the person landed on a large portion of the body (flat on his back, for example), the force of the fall was distributed more evenly across the surface of the body.

DeHaven concluded that injury could be reduced if the forces of the impact were spread out in time and space. In fact, spreading out the forces of the impact — and stretching them out over just a few hundredths of a second — could make the difference between life and death.

He therefore suggested that improved interior design and restraining devices such as seat belts would serve to stretch out the impact of a collision and to distribute the forces more evenly over the body. His ideas were eventually adopted in both automobile and aircraft designs.

### How Much Can People Take?

Others took up DeHaven's interest in the ability of the human body to tolerate crash forces. Colonel John Stapp of the U.S. Air Force became particularly well-known in the 1950s and 60s for his research on safety harnesses. Stapp was one of the first to initiate scientific testing of DeHaven's observations. He developed various crash simulators to test the upper limits of tolerance to the forces of deceleration. The best known of these was a high-speed rocket sled capable of speeds greater than 600 miles per hour.

Stapp's experiments showed that when properly belted, subjects could tolerate abrupt changes in speed that would otherwise cause serious injury. He demonstrated scientifically that the forces involved in many serious automobile and aircraft accidents could be survived without serious injury if seat belts were worn to restrain the occupants.

The findings of people like DeHaven and Stapp soon led automobile manufacturers to offer seat belts as optional safety equipment. By 1964 they were standard equipment in many American and European cars. Now all new cars sold in North America must be fitted with seat belts. It is estimated that about 90 percent of cars in Canada have seat belts.

### How Do Seat Belts Work?

In a 30-mile per hour crash test, the car takes about two feet to come to a stop. This is a fairly abrupt stop. The occupants usually stop over a much shorter distance, perhaps one to two inches. This difference in stopping distance means that the occupants will stop much more abruptly than the car.

To allow the body to come to a more gradual stop, all of the car's stopping distance has to be used. Holding the person in his seat with belts allows him to stop within about the same distance as the car. As a result, the forces on the body are greatly reduced.

The difference between the belted person's stopping distance and the unbelted person's stopping distance is often the difference between life and death. This is like the difference between one of DeHaven's fall victims landing on a sidewalk or in garden soil. The soft ground gives the person a few more inches in which to come to a stop. Seat belts give the person in the car an additional couple of feet in which to stop.

The lap belt keeps a person inside the car, protecting him from the many dangers of being "thrown clear". Even if used alone, the lap belt usually keeps the head from striking the windshield or windshield frame. It allows the body to bend

forward so that the head hits only the steering wheel or dashboard. These are designed to absorb energy and although their effect is somewhat limited, they do much less damage than harder structures. The lap belt allows the hips to absorb much of the force of the collision and thus reduces the force that the head or chest must absorb in hitting the steering wheel or dashboard.

The shoulder belt prevents the head and chest from hitting the steering wheel or dashboard. Together, the lap and shoulder belts work to keep a person in his seat and to distribute the force of the collision over the hips and shoulders — the parts of the body that can best withstand the force.



*On impact, the car begins to crush and to slow down.*



*As the car slows down, the person moves forward until the seat belts restrain him. The belts keep him in his seat and keep his head and chest from striking the car interior.*



*As part of the car, belted passengers are able to "ride down" the collision — to take advantage of the car's slower stop, as it crushes and absorbs energy. For belted passengers, there is no human collision.*

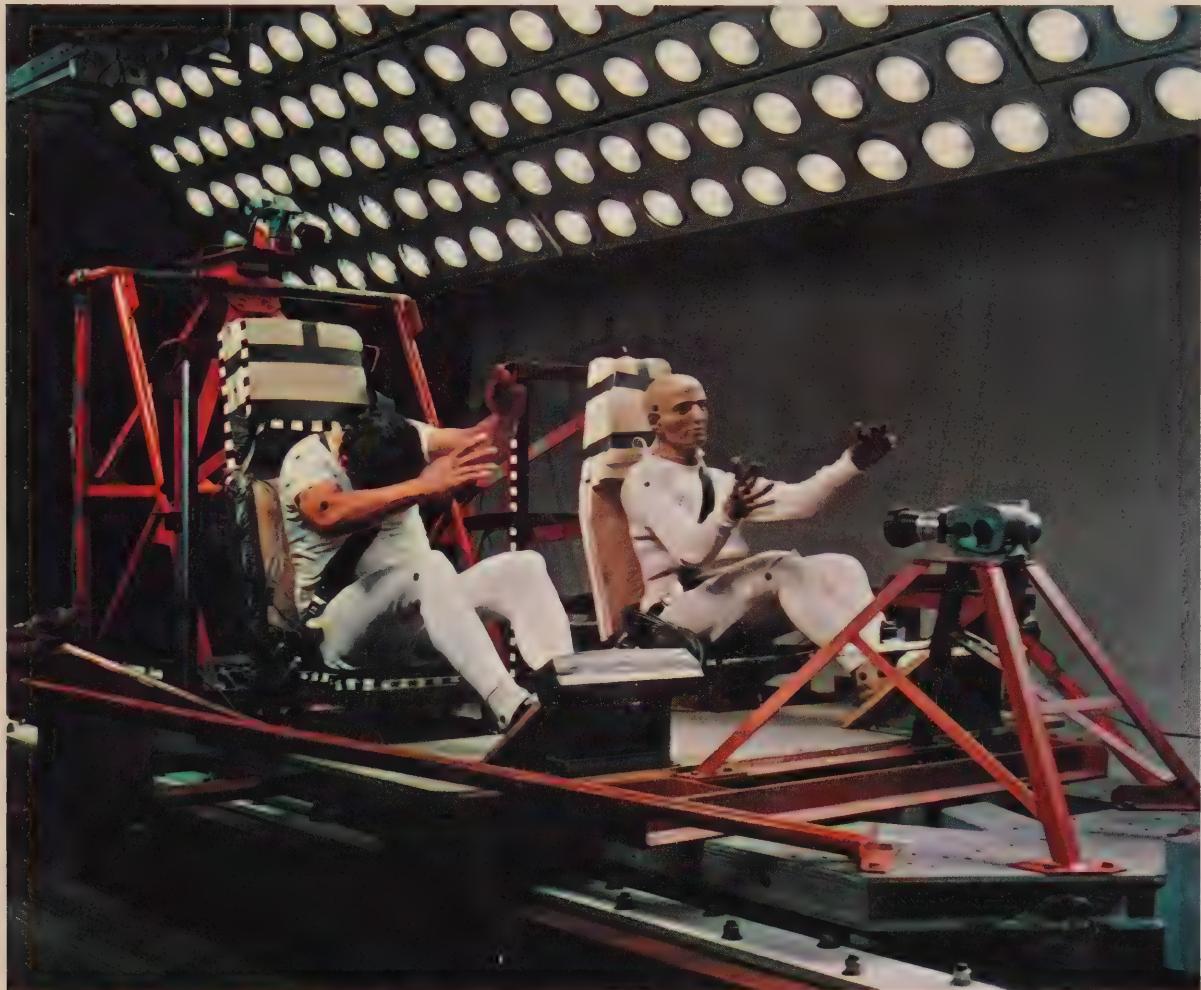
## Laboratory Evidence

Since the early research showed that seat belts could reduce injuries in automobile accidents, further research has gone into the testing and development of seat belt systems. A large body of evidence for the value of seat belts comes from different types of studies, all of which agree that seat belts greatly reduce injury and death. These studies include laboratory testing, controlled test-track crashes, on-the-scene accident investigations and investigations of accident records.

To simulate a real-life crash in a laboratory setting, dummies have been built to approximate the human body. The dummies ride in a crash simulator sled — a structure similar to that of a car frame. The sled runs along a track and is controlled so that it can be accelerated and stopped suddenly. In this way, the dummies can be subjected to forces similar to those that people experience in automobile accidents.



*This type of crash simulator sled uses an actual car body. The sled is controlled so that it can be accelerated and stopped suddenly to simulate the forces that occur in real collisions.*



*This crash sled simulates the forces of an actual collision. Sleds like this are well suited for use by human volunteers.*

The simulated crashes are filmed in extreme slow-motion to enable observation of what actually happens to the dummies in the crash. Instruments inside the dummies record the impact on various parts of the body. Tests with human volunteers are used to verify the beneficial effects of seat belts.

Test-track crashes are conducted using instrumented dummies and vehicles that are remotely controlled. Each car carrying belted or unbelted dummies is driven into another vehicle or a solid barrier. After each controlled crash, the instrument records and slow-motion film are examined to find out what happened to the car and to each of the dummy occupants.



Barrier crashes at various speeds are carried out to determine the effects of a collision on vehicles and on dummies which simulate human passengers.



Vehicle to vehicle crashes simulate common real-life collisions. Instrumentation and high-speed photography show how injuries occur.

## What the High-Speed Camera Shows



1

*Research engineer Michael Walsh awaits his ride on a crash simulator sled.*

2

*Impact! Walsh is thrown forward. The seat belt keeps him in his seat.*

3

*Here the forces of the collision are at their maximum. Notice the bulging of Walsh's stomach as the seat belt strains to hold him back.*



4

*The human collision has been avoided and Walsh's body begins to rebound.*

5

*Less than 1/10 of a second after impact, Walsh safely returns to his original position.*

6

*The speed of this simulated barrier collision was 17 mph!*

## Evidence From Real Accidents

Seat belts reduce forces and injuries to dummies and to humans in laboratory settings. However, this alone does not prove that they help people in real accidents. Real accidents are much more complex than controlled, laboratory collisions, but actual accidents have been studied and the findings all point to the benefit of seat belts.

Some of these studies involve on-the-scene investigations of accidents by teams of engineers and doctors. Both dead and injured persons are examined. The forces involved are estimated from damage sustained by the outside of the car. Damage to the car interior and the occupant are matched to determine the cause of injury. These accident investigation studies have all concluded that about half or more of the deaths and serious injuries would have been avoided if lap and shoulder belts had been worn.

In Metropolitan Toronto in 1970, 35 drivers and 22 passengers were killed in traffic accidents. None of them were wearing seat belts. An investigation of these fatal accidents concluded that more than half the deaths of both passengers and drivers could have been prevented if seat belts had been worn.

When large numbers of accident records were surveyed, it was again found that seat belts reduced injury and death by about half. In Sweden, a major study of 28,000 accident records was conducted in the mid-1960s. This study included all kinds of accidents, serious and minor, but only one make of car was involved. All vehicles were equipped with three-point lap and shoulder belts. The study found that belted people received about half as many injuries as unbelted people in collisions at all speeds. As expected, the greatest reductions were in head, face and chest injuries. No one wearing a seat belt was killed in any collision at speeds up to 60 miles per hour. Unbelted people were killed in collisions at speeds less than 20 miles per hour. (Refer to the graph showing the frequency of injuries sustained by drivers.)

The Swedish study is the most widely known of its type. However, similar studies have been done in North America and all have found that belts save lives and reduce injuries in all types of real collisions. Much of the benefit from belts in real accidents is due to the dramatic effect of lap and shoulder belts in reducing the most common, serious injuries — those to the head and chest.

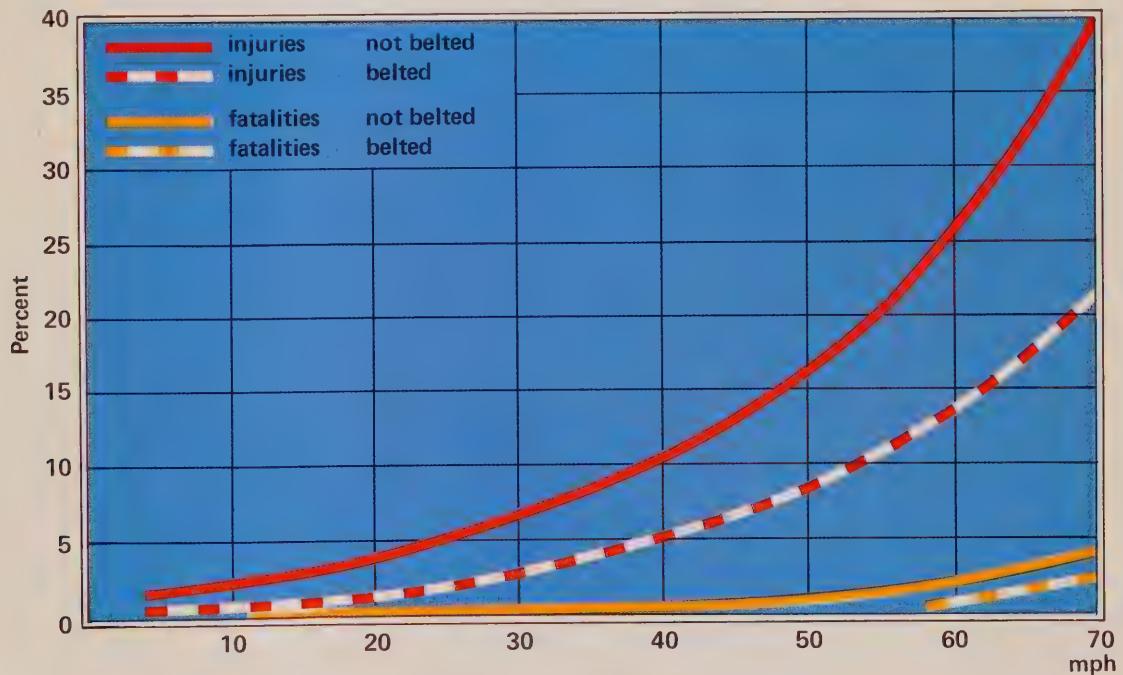


*Real accidents are more complex than controlled laboratory collisions.*



Transport Canada

Accidents are investigated by teams of engineers and doctors. Damage to the car interior is matched with the injuries received by the occupants to determine the causes of injuries or death.



A Swedish study showed that belted people received about half as many injuries as unbelted people in collisions at all speeds. (N.I. Bohlin, 1967)

## What About Children?

Because the small child has a relatively heavy head and fragile skull, he is very likely to suffer serious head injuries even in low-speed accidents. Seventeen percent of the car occupants killed or injured in Ontario in 1973 were children under the age of 14.

Children over the age of 5 or weighing over 50 pounds can wear a regular lap belt. Sitting the child on a firm cushion or pillow may help the lap belt fit lower on the child's hips. The cushion will also make him better able to see out of the car and make him less bored with the ride. Children who are less than 55 inches tall should not wear shoulder belts since the belt usually rides too high and could injure the child's neck.

Children under five or weighing less than 50 pounds need a special child restraint. This will spread crash forces evenly over the child's body and prevent him from being thrown forward into the dashboard or windshield. There are approved child restraints now available which have been tested and proven effective in protecting the child in most accidents.



*Unrestrained children are especially vulnerable to injury and death in car accidents. The responsibility lies with the adults to ensure that children are properly restrained.*

## In almost every case it's better to wear seat belts

In Ontario in 1973, 830 drivers died in accidents. The death rate for unbelted drivers was about 2.3 per 1,000 accident-involved drivers. The death rate for belted drivers was only 1.0 per 1,000. These figures show that belts cannot save everybody in all collisions. However, they are consistent with studies done elsewhere that show belts reduce the chances of death by more than half. Of the few belted drivers killed, some were undoubtedly wearing only lap belts and they could probably have been saved if they had worn both lap and shoulder belts.

Seat belts are more protective in some kinds of collisions than others. They are more effective in head-on and front-angled accidents and rollovers than in side or rear end collisions. They also tend to be more effective at speeds of less than 60 miles per hour. However, it has been shown that vehicle occupants are better off in a side collision if they are wearing their seat belts. Seat belts cannot always prevent fatal injuries in extremely high-speed accidents or those which involve direct contact with an object, such as a tree, entering the car. However, they are of some benefit in nearly all accidents.

Belts also help the driver to remain in his seat and in control of the car after a minor collision. This may prevent a second perhaps more serious accident.

Some earlier belt designs have been inconvenient for the user. However, the evidence clearly indicates seat belts are worth the trouble it takes to use them. Also, design requirements for 1974 cars have made belts more comfortable and easier to wear.

### The Dangers of Being "Thrown Clear"

The human collision can also take place outside the car — if the person goes out through the windshield, side window or door.

Various studies have investigated whether it is better to be "thrown clear", as some people claim. The risk of death or serious injury is many times greater if the person is thrown out of the car. About one-quarter of all passenger and driver-deaths result from being thrown out. One study estimated that about 80 percent of these deaths could have been prevented if the person had stayed in the car.

Those who believe that it is safer to be thrown out of the car should consider why motorcycle accidents are so dangerous. Motorcyclists suffer an extremely high rate of injury and death in their accidents because they are "thrown clear" nearly every time.

The world outside the car is very dangerous for a fast moving, unprotected human body.



*The risk of death or serious injury is greatly increased if the person is thrown out of the car.*



*This car was involved in a rollover accident. It rolled six times before coming to a stop. The driver was fatally injured as a result of being thrown out the back window.*

## The Importance of Remaining Conscious

People often say they don't wear their belts because they are afraid of being trapped in a burning car or a car submerged in water. Actually, the occurrence of fire or submersion is rare, especially when compared to the danger from the human collision which occurs in every accident. Rather than trapping the occupants, seat belts help them remain conscious and thus able to get out of the car quickly. You cannot escape from a burning or sinking car if you are lying on the floor with a fractured skull.

In Ontario, in 1973, no belted drivers died in a car that burned or that was submerged in water. Forty-three drivers who were wearing seat belts died in traffic accidents. Most of the 43 died in high-speed head-on and side collisions. It is likely that most of these accidents were just so severe that they were unsurvivable. However, some of the drivers might have been saved if they had been using their shoulder belt as well as their lap belt.

## The Importance of Being Properly Belted

Belted occupants may occasionally receive injuries from the belts themselves, however, these injuries tend to be minor. Bruises, slight rib fractures, muscle strain and soreness, and intra-abdominal injuries are much more acceptable than the injuries which occur when vehicle occupants are not wearing seat belts.

Injuries from seat belts usually result from incorrect adjustments for instance, wearing the lap belt too loose, too high on the abdomen or twisted. The lap belt should be worn snug over the hips and the shoulder belt should be worn loose enough to allow an inch or two between the belt and the chest.

Unlike other questions involving seat belts, there has been some controversy among experts as to whether pregnant women should wear seat belts. The medical profession, however, now supports the proper use of seat belts by pregnant women. Seat belts worn properly (low under the abdomen) provide considerable protection for pregnant women. The most frequent cause of death in car accidents for the unborn child is the death of the mother. The best way to protect the unborn child is to ensure the survival of the mother — and seat belts are the best way to do this.



*To be effective, seat belts must be worn correctly. The lap belt should be worn low and snug over the hips. The shoulder belt should have no more than two inches of slack.*

## Are Belts Necessary at All Times?

Many people wear seat belts only on long trips or when weather conditions seem particularly dangerous. Serious accidents, however, occur at all speeds, on all kinds of trips and under all kinds of conditions.

The accident rate is low on expressways where much high-speed, long-distance travelling takes place. Short trips on urban and rural roads are potentially more dangerous even though the traffic speeds are lower. Also, most people drive locally a great deal more than they drive long distances. Thus, the chances of being in an accident close to home are greater.

Many accidents occur when visibility is poor or roads are slippery but most serious accidents, those that cause injury or death, occur under clear and dry conditions. The majority of fatal accidents take place at moderate speeds. The months in which the most fatal accidents occur are in late summer and early fall when the weather in Ontario is usually favorable.

The only way to gain full benefit from seat belts is to make a habit of using them on every trip.



*This is a laboratory simulation of a barrier crash. The human volunteer is safely belted in his seat but the unbelted dummy has moved forward and struck his head on the windshield.*



*It's hard to believe that a crash at 11 mph could have serious consequences like this.*

# Personal risk

Every person who uses the roads risks injury or death. It is certainly not pleasant to contemplate the possibility of being killed each time you drive your car, but the risk is real.

Of all the people now living in Ontario, 12.5 percent (962,886) will be killed or injured in a motor vehicle accident within the next ten years. Over the next forty years, 32 percent of the current population will be killed or injured. That's more than two and one-half million people.

Over a lifetime, a person has more than a fifty/fifty chance of being injured in a car accident.

There are many things that will reduce your own risk. You can drive very carefully. You can avoid driving after drinking. You can keep your car in peak condition. You could even drive less. None of these steps, however, will guarantee you against an accident.

Good drivers have accidents too, sometimes because they are hit by drunk drivers or other poor drivers, sometimes because they make an error. Nobody is immune to accidents.

No one can control all of the factors involved in a traffic collision. But there is a simple and effective way of cutting your risk by more than half — wear your seat belts.



*Every person who uses the roads risks injury or death.*



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## WHAT HAPPENS IN A COLLISION

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# Let us hear from you

We would like to know your reactions to the content of this booklet. Please answer the following questions and add your comments at the end. Fold this card and staple or tape it together. The card is pre-addressed and postage is paid. We would appreciate your reply.

1. How would you describe your own seat belt usage within the last year?

ALWAYS \_\_\_\_ USUALLY \_\_\_\_ OFTEN \_\_\_\_ SOMETIMES \_\_\_\_ NEVER \_\_\_\_

2. Did you read the entire booklet?

YES \_\_\_\_ NO \_\_\_\_

3. Did you find the booklet easy to understand?

YES \_\_\_\_ NO \_\_\_\_

4. Has this booklet changed your opinion about wearing seat belts?

YES \_\_\_\_ NO \_\_\_\_

5. Did you get any new information about seat belts from the booklet?

YES \_\_\_\_ NO \_\_\_\_

6. Do you think it is a good idea to use seat belts?

YES \_\_\_\_ NO \_\_\_\_

WHY? \_\_\_\_\_  
\_\_\_\_\_

7. Do you have any comments about the photos and illustrations in the booklet?

\_\_\_\_\_

8. We would appreciate any further comments, suggestions or questions about seat belts or the booklet.

\_\_\_\_\_

MALE \_\_\_\_ FEMALE \_\_\_\_ AGE \_\_\_\_ OCCUPATION \_\_\_\_\_

Would you like more material on seat belts? If so, please check the following that would be of interest.

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